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# Bacterial Mutagenicity of Urban Organic Aerosol Sources in Comparison to Atmospheric Samples

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The bacterial mutagenicity of a comprehensive set of urban particulate air pollution source samples is examined using the *Salmonella typhimurium* forward mutation assay. Each of the combustion source samples examined, including the exhaust from catalyst-equipped autos, noncatalyst autos, heavy-duty diesel trucks, plus natural gas, distillate oil, and wood combustion sources, is mutagenic in this assay, with a response per microgram of organic carbon in these samples generally greater than that of cigarette smoke aerosol. The noncombustion source samples tested generally are not mutagenic at the levels examined. The specific mutagenicity (mutant fraction per microgram of organic carbon) of ambient aerosol samples collected in southern California is compared to a weighted average of the specific mutagenicity of the primary source samples assembled in proportion to their emission rates in the Los Angeles area. In most cases where a comparison can be made, the specific mutagenicity of the source composites and the ambient samples are of similar magnitude, with the exception that the -PMS mutagenicity of the aerosol at Long Beach, CA, during the first half of the calendar year 1982 and at Azusa, CA, during the April-June 1982 period is much higher than can be explained by direct emissions from the sources studied here.

## *Introduction*

Particulate organic compounds are emitted to the urban atmosphere from a wide variety of air pollution sources. There are fossil fuel combustion sources, both stationary and mobile, including industrial boilers, home heaters, and gasoline- and diesel-powered vehicles. Their effluents are mixed in the atmosphere with fugitive dusts that contain organic compounds, including paved road dust, tire wear debris, and brake lining wear particles. Domestic activities such as food cooking operations (e.g., charbroiling of meat), fireplace combustion of wood, and even cigarette smoke add aerosol carbon emissions to the atmosphere.

The resulting atmospheric mixture of directly emitted organic aerosol thus consists of small contributions from a large number of sources. Each of these source effluents in turn consists of a complex mixture of organic compounds. Many of the individual chemical compounds, of greatest interest because of their possible mutagenic or carcinogenic potential, are present in small quantities such that their identification is made very difficult by the presence of the complicated chemical matrix consisting of hundreds of more abundant but less hazardous substances that are found in most environmental samples.

Biological assay procedures have been developed for use as screening tools that help to focus further investigation on those contributors to complex environmental samples that are capable of producing measurable biological changes. Bacterial mutagenicity assays (*1*, *2*) often are used at an early stage in such a screening program and can be followed by mutagenicity studies conducted in human cells (*3*) and in test animals (*4*). Through such procedures it has been shown that particulate matter filtered from ambient air is a bacterial mutagen (*5-7*) and that certain direct emission sources of organic aerosols, including diesel engine exhaust (*8*), wood smoke (*9-11*), and cigarette smoke (*12*, *13*), likewise contain mutagenic compounds. Bioassay-directed chemical analysis procedures have been developed that use bacterial mutagenicity assays in conjunction with chemical separation and analysis procedures to identify the chemical compounds within complex samples that are responsible for the observed mutagenic response (*14-19*). Such bioassay-directed chemical analysis also has been developed as a tool for studying the atmospheric transformations that create or destroy mutagenic compounds due to atmospheric chemical reactions (*20*).

Comparison of the relative mutagenicity of air pollution sources and ambient samples based on the present scientific literature is difficult because differences in the procedures used by different laboratories can mask actual differences between different pollutant source effluents. A recent collaborative study by the International Programme on Chemical Safety (IPCS) (*21-23*), a subgroup of the World Health Organization (WHO), found that 55-95% of the variability seen in the mutagenicity of three environmental mixtures tested could be accounted for by between-laboratory variations in procedures rather than by actual differences in the samples. The ability to compare source and ambient aerosol mutagenicity results reported in the literature is further limited by the fact that no uniformity exists in methods for sample collection, storage, and extraction.

In this paper, we report a study of the bacterial mutagenicity of a comprehensive set of urban particulate air pollution source samples. Fifteen major air pollution source types are examined that directly account for approximately 70% of the primary organic aerosol emissions to the Los Angeles area atmosphere as described by Hildemann *et al.* (*24*). Comparison is made to the mutagenicity of ambient particulate samples collected by Gray *et al.* (*25*) by methods similar to the source sampling procedures. Through careful matching of source and ambient sampling methods and by subjecting all samples simultaneously to identical extraction and bioassay procedures in the same laboratory, variations in test results due to changes in methods have been minimized. The bacterial mutation assay used in this study is a version of the *Salmonella typhimurium* forward mutation assay developed by Skopek *et al.* (*2*).



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